# CORPS OF ENGINEERS
# KANSAS CITY DISTRICT OFFICE

# ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP) BOILER AND CHILLER PLANTS FORT LEONARD WOOD, MISSOURI

Contract No. DACA41-86-C-0015

## FINAL SUBMITTAL

EXECUTIVE SUMMARY

Prepared By:
Lutz, Daily & Brain
Consulting Engineers
Shawnee Mission, Kansas



December 1988

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited.
Distribution A. Approved for public release.

Marie Wakefield,
Librarian Engineering

LUTZ, DAILY & BRAIN CONSULTING ENGINEERS
CLOVERLEAF 4 BLDG., 6400 GLENWOOD, OVERLAND PARK, KANSAS
TELEPHONE 913 • 831-0833 TWX 910-743-4190

MAILING ADDRESS:
P.O. BOX 718
SHAWNEE MISSION,
KANSAS 66201

**KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS**
**ENERGY ENGINEERING ANALYSIS PROGRAM**
**FORT LEONARD WOOD, MISSOURI**
**BOILER/CHILLER PLANTS**

**Final Submittal, 12/88**
**Detailed Instructions to Update**
**Executive Summary**

1. Replace the green title sheet.
2. Replace page i, Table of Contents.
3. Replace page 1, Introduction.
4. Replace page 2, Acknowledgment.
5. Replace page 3, Table I.
6. Replace pages 4, 5, 6 and 7, Table II
7. Insert page 8, Ft. Leonard Wood Map.
8. Insert pages 9, 10, 11, 12 and 13, Table III.
9. Insert page 14, Table IV.
10. Remove pages 8 through 17 and insert pages 15 through 24, Annual Energy Savings.
11. Remove pages A-2 through A-8 and replace them with pages A-2 through A-8, LCCA Summary Sheets.

**TABLE OF CONTENTS**
**FOR**
**EXECUTIVE SUMMARY**

# I. EXECUTIVE SUMMARY

## A. INTRODUCTION

Lutz, Daily & Brain Consulting Engineers was commissioned by the United States Army Corps of Engineers (COE) to develop an Energy Engineering Analysis Program (EEAP) of the Fort Leonard Wood Boiler and Chiller Plants. The EEAP consists of several phases including but not limited to data collection, data refinement, on-site inspection, concept development, performance testing, preparation of programming documents, and documentation of alternatives and recommendations. The Scope of Work (SOW) of this Contract has been modified to include the use of propane instead of No. 6 fuel oil for the feasible Energy Conservation Opportunities (ECO) calculations. This fuel change was analyzed because the Base has initiated a program of switching from No. 6 fuel oil to liquid propane for all of their boiler plants. The results of all ECO calculations using No. 6 fuel oil have been included at the request of the COE for record purposes. Nonfeasible ECO's were not rerun for propane, because changing the fuel from No. 6 fuel oil to propane, a higher cost fuel, would not make the ECO's feasible. This submittal presents finding of the EEAP and provides recommendations for implementation.

1. In detail this report presents the following information:

   Determine the efficiency of the boiler/chiller plants by appropriate tests.

   Survey the boiler/chiller plants to determine if the efficiency can be improved by the repair, addition, or modification of equipment and recommend improvements.

   Evaluate the control system and recommend changes, repairs, or new controls which will improve the efficiency of the plants.

   Review operation and maintenance procedures and provide site specific recommendations which will increase the efficiency of the plants to the maximum level.

   Prepare programming and implementation documents.

   Prepare a comprehensive report to document the work performed, the results, and recommendations.

   List all Energy Conservation Opportunities (ECO) and perform complete evaluations, including low cost/no cost items.

   Tabulate project documentation for Military Construction Projects (DD Form 1391) and Project Development Brochure (PDB).

   List implementation documentation for all justifiable energy conservation opportunities.

List and priorities for all recommended energy conservation projects.

2. Implementation of the measures outlined herein will result in substantial improvement in operations cost of the Fort Leonard Wood Boiler and Chiller Plants. Modifications to the Boiler and Chiller Plants identified within the study include:

   Direct digital chiller controls.
   Flue gas monitoring and oxygen trim.
   Burner and burner controls replacement.
   Installation of economizers.
   Replacement of chillers.

3. Acknowledgements

Lutz, Daily & Brain wishes to acknowledge the cooperation of Ms. Christine Hendzlik, Project Manager, Mr. Jack DeShurly, the Point of Contact at Fort Leonard Wood and numerous other boiler/chiller plant personnel.

4. The study is organized into the following eight volumes plus an Executive Summary and Programming and Implementation Documentation.

| Volume | Description |
|---|---|
| -- | Executive Summary |
| -- | Programming and Implementation Documentation |
| 1 | Summary |
| 2 | Building 311 Boilers |
| 3 | Building 645 Boilers |
| 4 | Building 745 Boilers |
| 5 | Building 1021 Hot Water Generator Units |
| 6 | Building 2351 Boilers |
| 7 | Building 2369 Hot Water Generator Units |
| 8 | Chillers |

5. Energy Conservation Opportunities' Descriptions and Packaging

Table I is a list of the project types prioritized by SIR. The grouping of the ECOs into each of these projects is as requested by Mr. Jack DeShurley. All of the feasible ECOs prioritized by Savings to Investment Ratio (SIR) are listed in Table II. Table II also lists the Simple Amortization Period (SAP) and the Estimated Replacement Cost. Table III lists the locations, capacities and other information on the equipment involved in this report. Table IV lists possible percent energy savings by building if feasible ECOs are implemented. Figure Nos. 1, 2, 3, 4, 5 and 6 are graphical representations of the estimated annual energy savings for the feasible ECOs. Appendix A of this summary includes the backup calculations for the data that is presented in Table II.

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE I

BOILER/CHILLER PLANTS PROJECT PACKAGING

| Project Type | ECO Nos. | Estimated Cost | Average SIR | Average SAP | Description |
|---|---|---|---|---|---|
| ECIP | 7P,9P, 10P,11P, 15P,18P | $490,000 | 2.65 | 6.40 | Boilers-Burner & Burner Controls |
| ECIP | 14P,16P, 17P,20P | $333,000 | 2.00 | 7.53 | Boilers-Economizers |
| ECIP | 21,22,23 | $784,040 | 1.82 | 6.51 | Chillers-Replacement |
| QRIP | 1,6,4,12 | $133,000 | 6.35 | 1.59 | Chillers - Direct Digital Control to Operate Chillers and Auxiliaries |
| Low Cost/No Cost (LC/NC) | 2P | $ 3,400 | 6.28 | 2.72 | Flue Gas Analyzer |
| LC/NC | 3P,5P,8P, 13P,24P | $ 98,325 | 3.26 | 5.23 | Boilers - Flue Gas Monitoring and Oxygen Trim |
| LC/NC | 19P | $ 19,665 | 2.63 | 6.50 | Boilers - Flue Gas Monitoring and Oxygen Trim |

Refer to Table II for additional description of ECOs.

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE II

FEASIBLE ENERGY CONSERVATION OPPORTUNITIES (ECO)
(These evaluations are based on Propane Fuel and 1,110 Hours of Chiller Operation)

| ECO | Description | SAP | SIR | Estimated Replacement Cost |
|---|---|---|---|---|
| 1. | Bldg 1021 - Direct Digital Controls | 1.08 | 9.28 | $18,000 |
| 6.* | Bldg 311 - Direct Digital Controls | 1.24 | 8.09 | $45,000 |
| 2P. | Portable flue gas analyzer | 2.72 | 6.24 | $ 3,400 |
| 4. | Bldg 2369 - Direct Digital Controls | 2.08 | 4.83 | $35,000 |
| 3P. | Bldg 745, Blr No. 1 - Flue gas monitoring equipment and oxygen trim in conjunction w/burner replacement | 3.90 | 4.34 | $19,700 |
| 5P. | Bldg 645, Blr No. 3 - Flue gas monitoring equipment and oxygen trim in conjunction w/burner replacement | 4.09 | 4.14 | $19,700 |
| 12. | Bldg 745-Direct Digital Controls | 2.50 | 4.00 | $35,000 |
| 8P. | Bldg 1021, HW Generators A&B - Flue gas monitoring equipment and oxygen trim in conjunction w/burner replacement | 6.96 | 2.44 | $ 39,400 |
| 7P. | Bldg 645, Blr No. 3 - Burner and burner controls | 4.87 | 3.48 | $74,000 |
| 9P. | Bldg 745, Blr No. 1 - Burner and burner controls | 5.29 | 3.20 | $79,000 |
| 10P. | Bldg 745, Blr No. 5 - Burner and burner controls | 5.39 | 3.15 | $79,000 |
| 11P. | Bldg 745, Blr No. 4 - Burner and burner controls | 5.41 | 3.13 | $79,000 |

*Based on 4,000 hours operation at request of installation.

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE II (Continued)

ENERGY CONSERVATION OPPORTUNITIES (ECO)
(These evaluations are based on Propane Fuel and 1,110 Hours of Chiller Operation)

| ECO | Description | SAP | SIR | Estimated Replacement Cost |
|---|---|---|---|---|
| 15P. | Bldg 1021, HW Generator A - Burner and burner controls | 5.48 | 3.10 | $ 48,000 |
| 21. | Bldg 311 - Chillers | 3.60 | 2.78 | $268,700 |
| 13P. | Bldg 745, Blr No. 5 - Flue gas monitoring equipment and oxygen trim in conjunction w/burner replacement | 5.96 | 2.85 | $ 19,700 |
| 14P. | Bldg 745, Blr No. 5 - Economizer | 5.95 | 2.53 | $ 70,100 |
| 16P. | Bldg 745, Blr No. 1 - Economizer | 6.09 | 2.47 | $ 70,100 |
| 17P. | Bldg 745, Blr No. 4 - Economizer | 6.16 | 2.45 | $ 70,100 |
| 18P. | Bldg 1021, HW Generator B - Burner and burner controls | 5.74 | 2.95 | $ 48,000 |
| 19P. | Bldg 745, Blr No. 4 - Flue gas monitoring equipment and oxygen trim | 6.50 | 2.61 | $ 19,700 |
| 20P. | Bldg 645, Blr No. 3 - Economizer | 7.00 | 2.15 | $ 66,700 |
| 22. | Bldg 1021 - Chillers | 8.03 | 1.25 | $232,100 |
| 23. | Bldg 2369 - Chillers | 8.16 | 1.23 | $283,240 |
| 254* | Instrumentation for Bldg 311 Blrs | -- | -- | $ 6,900 |
| 271* | Design Information | -- | -- | -- |

*ECO's that do not have tangible benefits, but would be advantageous if performed, are listed without calculations or a feasibility determination.

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE II (Continued)

ENERGY CONSERVATION OPPORTUNITIES (ECO)
(These evaluations are based on Propane Fuel
and 1,110 Hours of Chiller Operation)

| ECO | Description | SAP | SIR | Estimated Cost |
|---|---|---|---|---|
| 272* | Monitor Boiler Efficiency | -- | -- | -- |
| 273* | Log Books | -- | -- | -- |
| 274* | Boiler Servicing | -- | -- | -- |
| 352* | Instrumentation for Bldg 645 Blrs | -- | -- | $12,420 |
| 371* | Design Information | -- | -- | -- |
| 372* | Monitor Boiler Efficiency | -- | -- | -- |
| 373* | Log Books | -- | -- | -- |
| 374* | Boiler Servicing | -- | -- | -- |
| 375* | Boiler Loading | -- | -- | -- |
| 452* | Instrumentation for Bldg 745 Blrs | -- | -- | $12,420 |
| 471* | Design Information | -- | -- | -- |
| 472* | Monitor Boiler Efficiency | -- | -- | -- |
| 473* | Log Books | -- | -- | -- |
| 474* | Boiler Servicing | -- | -- | -- |
| 475* | Boiler Loading | -- | -- | -- |
| 552* | Instrumention for Bldg 1021, HW Gen Units | -- | -- | $10,120 |
| 571* | Design Information | -- | -- | -- |

*ECO's that do not have tangible benefits, but would be advantageous if performed, are listed without calculations or a feasibility determination.

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

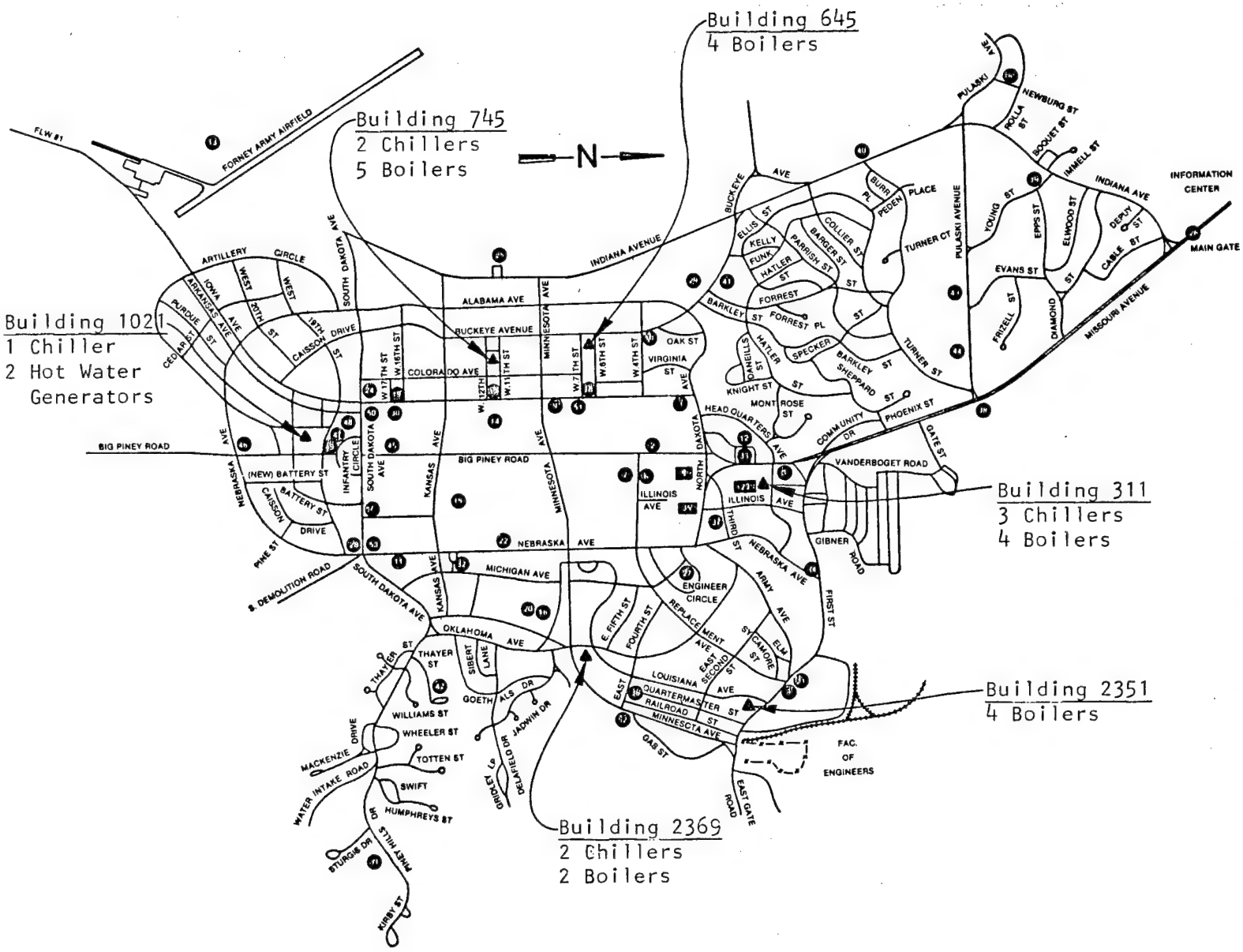
TABLE II (Continued)

ENERGY CONSERVATION OPPORTUNITIES (ECO)
(These evaluations are based on Propane Fuel
and 1,110 Hours of Chiller Operation)

| ECO | Description | SAP | SIR | Estimated Cost |
|---|---|---|---|---|
| 572* | Monitor Boiler Efficiency | -- | -- | -- |
| 573* | Log Books | -- | -- | -- |
| 574* | Boiler Servicing | -- | -- | -- |
| 662* | Insulation on Steam and Feedwater Piping for Bldg 2351 | -- | -- | -- |
| 654* | Boiler Control, butterfly valve and linkage on gas train, Bldg 2351, Blrs 1 and 2 | -- | -- | $ 4,500 |
| 652* | Instrumentation for Bldg 2351 Blrs | -- | -- | $ 1,380 |
| 671* | Design Information | -- | -- | -- |
| 672* | Monitor Boiler Efficiency | -- | -- | -- |
| 673* | Log Books | -- | -- | -- |
| 752* | Instrumentation for Bldg 2369, HW Gen Units | -- | -- | $10,120 |
| 771* | Design Information | -- | -- | -- |
| 772* | Monitor Boiler Efficiency | -- | -- | -- |
| 773* | Log Books | -- | -- | -- |
| 774* | Boiler Servicing | -- | -- | -- |

*ECO's that do not have tangible benefits, but would be advantageous if performed, are listed without calculations or a feasibility determination.

# FORT LEONARD WOOD




**LEGEND**

1. BUILDING 315
   IN PROCESSING
   ACS WELCOME CENTER
   CIVILIAN PERSONNEL OFFICE
   HOUSING DIVISION
   TRANSPORTATION DIVISION
2. BUS DEPOT (496 AND 497)

**CHAPELS**

3. POST CHAPEL (450)
4. RECEPTION STATION CHAPEL (2366)
5. COMMISSARY (498)
6. CRAWFORD BOWLING CENTER (493)
7. DAUGHERTY BOWLING CENTER (1609)
8. DAY CARE CENTER (6824)

**DENTAL CLINICS**

9. BOAK (606)
10. HARPER (500)
11. ROLL (1608)
12. FINANCE (408)
13. FORNEY ARMY AIRFIELD (3197)
14. GAMMON FIELD
15. GERLACH FIELD

**HEADQUARTERS**

16. HEADQUARTERS COMPANY (1704)
    TNG SPT (1704)
17. 2D TRAINING BRIGADE, OST (741)
18. 3D BASIC TRAINING BRIGADE (636)
19. 4TH TRAINING BRIGADE (844)
20. 5TH ENGINEER BATTALION (1703)
21. US ARMY RECEPTION STATION (2362)
22. HILLTOPPER STADIUM
23. HOSPITAL (GEN. LEONARD WOOD ARMY)(310)
24. ID CARD SECTION (838)
25. INDIANA PARK
26. MAIN GATE
27. MILITARY POLICE COMMAND (2055)
28. MUSEUM (1307)
29. NCO CLUB (7391)
30. NUTTER FIELD HOUSE (1067)
31. OFFICERS CLUB (4109)
32. OUTDOOR RECREATION CENTER (1852)
33. POST HEADQUARTERS (401)
34. POST LOCATOR (282)
35. POST EXCHANGE (MAIN PX)(490)
36. CLOTHING SALES (2319)
37. PX GARAGE (204)
38. PX GAS STATION (2576)

**SCHOOLS**

39. PARTRIDGE (7078)
40. PERSHING (7077)
41. PICK (7801)
42. THAYER (4375)
43. WILLIAMS (7075)
44. WOOD JR. HIGH (7078)
45. TRAINING AID SUPPORT CENTER (TASC)(801)
46. DEVICES BRANCH (1448)
47. GRAPHICS BRANCH (1412)
48. SILK SCREEN SHOP (1413)
49. PHOTOGRAPHIC BRANCH (1411)

**THEATERS**

50. ABRAMS (804)
51. BAKER (2128)
52. VETERINARY CLINIC (2399)
53. WALKER RECREATION CENTER (1607)
    LIBRARY

NOTE: See Table III for Equipment Descriptions.





★U S GPO 1985-0 564-012/13683

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE III

CHILLER AND BOILER TABULATION BY BUILDING

Building 311

| Chiller No. | 1 | 2 | 3 |
|---|---|---|---|
| Manufacturer | York | Carrier | Carrier |
| Type | York Hermetic Turbopak | Centrifugal 19DK6174CM | Centrifugal 19DK6174CM |
| Model | HTM2G1-GAA | | |
| Compressor Model | MKA 65 | | |
| Compressor Serial No. | EM-05855 | | |
| Manufacture Date | 1975 | | |
| Nominal Tons | 750 | 300 | 300 |

Building 745

| Chiller No. | 1 | 2 |
|---|---|---|
| Manufacturer | Chrysler | Carrier |
| Type | Chrysler Air Temp Centrifugal | Hermetic Centrifugal Water Chiller |
| Model | C2SR989-2 | 19EA8273DL |
| Serial No. | 5B112341 | 775226867 |
| Manufacture Date | 1975 | 1977 |
| Nominal Tons | 960 | |

Building 1021

| Chiller No. | 1 |
|---|---|
| Manufacturer | Carrier |
| Type | Centrifugal Chiller |
| Model | 19C860 |
| Serial No. | 690613472 |
| Manufacture Date | 1969 |
| Nominal Tons | 1050 |

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE III (Continued)

CHILLER AND BOILER TABULATION BY BUILDING

Building 2369

| Chiller No. | 1 | 2 | 3 |
|---|---|---|---|
| Manufacturer | York | York | |
| Type | Hermetic Turbopak Liquid Chilling Unit | Hermetic Turbopak Liquid Chilling Unit | |
| Model | HTN3GL-GBB | HTN3GL-GBB | |
| Compressor Serial No. | FM-091147 | FM-091148 | |
| Manufacture Date | 1976 | 1976 | |
| Nominal Tons | 910 | 910 | |

Building 311

| Boiler No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Manufacturer | Kewanee | Kewanee | Titusville | Keeler |
| Type | Marine Type | Marine Type | Fire Tube | Water Tube |
| Year Built | 1984 | 1984 | 1963 | 1963 |
| Year Installed | 1984 | 1984 | 1963 | 1963 |
| Firing Equipment | Auto | Auto | Auto | Auto |
| Fuel | #6 oil | #6 oil | #6 oil | #6 oil |
| W/Pressure Design | 150 | 150 | 125 | 200 |
| Allowable Pressure | 150 | 150 | 125 | 200 |
| Safe/Valve Set | 125 | 125 | 125 | 110/115 |
| Serial No. | B4293 | R4724 | 40838 | 15889 |
| Heating Surface | | | | |
| Boiler | 1500 | 1500 | Unknown | 1735 |
| Water Wall | | | Unknown | 337 |
| Output (Btu/hr) | 10.043 million steam | 10.043 million steam | 7.17 million steam | 10.75 million steam |

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE III (Continued)

CHILLER AND BOILER TABULATION BY BUILDING

Building 645

| Boiler No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Manufacturer | Keeler | Keeler | Keeler | Titusville |
| Type | Water Tube | Water Tube | Water Tube | Water Tube |
| Year Built | 1959 | 1959 | 1959 | 1963 |
| Year Installed | 1959 | 1959 | 1959 | 1963 |
| Firing Equipment | Auto | Auto | Auto | Auto |
| Fuel | #6 oil | #6 oil | #6 oil | #6 oil |
| W/Pressure Design | 160 | 160 | 160 | 160 |
| Allowable Pressure | 160 | 160 | 160 | 160 |
| Safe/Valve Set | 135/140 | 135/140 | 135/140 | 135/140 |
| Serial No. | 13500 | 13501-1 | 13501-2 | 40883 |
| Heating Surface | | | | |
| Boiler | 1275 | 2648 | 2648 | 2642 |
| Water Wall | 275 | 422 | 422 | 432 |
| Output (Btu/hr) | 10.7 million steam | 21.5 million steam | 21.5 million steam | 21.5 million steam |

Building 745

| Boiler No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Manufacturer | Erie City | Erie City | Erie City | Erie City |
| Type | Water Tube | Water Tube | Water Tube | Water Tube |
| Year Built | 1965 | 1963 | 1964 | 1966 |
| Year Installed | 1965 | 1963 | 1964 | 1966 |
| Firing Equipment | Auto | Auto | Auto | Auto |
| Fuel | #6 oil | #6 oil | #6 oil | #6 oil |
| W/Pressure Design | 160 | 160 | 160 | 160 |
| Allowable Pressure | 160 | 160 | 160 | 160 |
| Safe/Valve Set | 134/141/144 | 138/141 | 135/140 | 130/135/140 |
| Serial No. | 1778 | 1521 | 1520 | 1779 |
| Heating Surface | | | | |
| Boiler | Unknown | Unknown | Unknown | Unknown |
| Water Wall | Unknown | Unknown | Unknown | Unknown |
| Output (Btu/hr) | 29 million steam | 19.9 million steam | 19.9 million steam | 29 million steam |

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE III (Continued)

CHILLER AND BOILER TABULATION BY BUILDING

Building 745, Continued

| Boiler No. | 5 |
|---|---|
| Manufacturer | Erie City |
| Type | Water Tube |
| Year Built | 1966 |
| Year Installed | 1966 |
| Firing Equipment | Auto |
| Fuel | #6 oil |
| W/Pressure Design | 160 |
| Allowable Pressure | 160 |
| Safe/Valve Set | 130/135/140 |
| Serial No. | 1780 |
| Heating Surface | |
| Boiler | Unknown |
| Water Wall | Unknown |
| Output (Btu/hr) | 29 million |

Building 1021

| Hot Water Generator | A | B |
|---|---|---|
| Manufacturer | Flo-Kontrol | Flo-Kontrol |
| Type | Water Tube | Water Tube |
| Year Built | 1969 | 1969 |
| Year Installed | 1969 | 1969 |
| Firing Equipment | Auto | Auto |
| Fuel | #6 oil | #6 oil |
| W/Pressure Design | 500 | 500 |
| Allowable Pressure | 500 | 500 |
| Safe/Valve Set | | |
| Serial No. | 186 | 187 |
| Heating Surface | | |
| Total | 5500 | 5500 |
| Output (Btu/hr) | 46,000,000 | 46,000,000 |

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE III (Continued)

CHILLER AND BOILER TABULATION BY BUILDING

Building 2351

| Boiler No. | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Manufacturer | Bigelow | Bigelow | Cleaver Brooks | Cleaver Brooks |
| Type | Water Tube | Water Tube | Fire Tube | Fire Tube |
| Year Built | 1966 | 1966 | 1972 | 1972 |
| Year Installed | 1966 | 1966 | 1972 | 1972 |
| Firing Equipment | Auto | Auto | Auto | Auto |
| Fuel | LP gas | LP gas | #2 oil | #2 oil |
| W/Pressure Design | 160 | 160 | 200 | 200 |
| Allowable Pressure | 160 | 160 | 200 | 200 |
| Safe/Valve Set | 140/145 | 140/145 | 125 | 125 |
| Serial No. | 12734 | 12734 | L-55457 | L-55458 |
| Heating Surface | | | | |
| Boiler | 2280 | 2280 | Unknown | Unknown |
| Water Wall | 326 | 326 | Unknown | Unknown |
| Output (Btu/hr) | 17.2 million steam | 17.2 million steam | 14.8 million steam | 14.8 million steam |

Building 2369

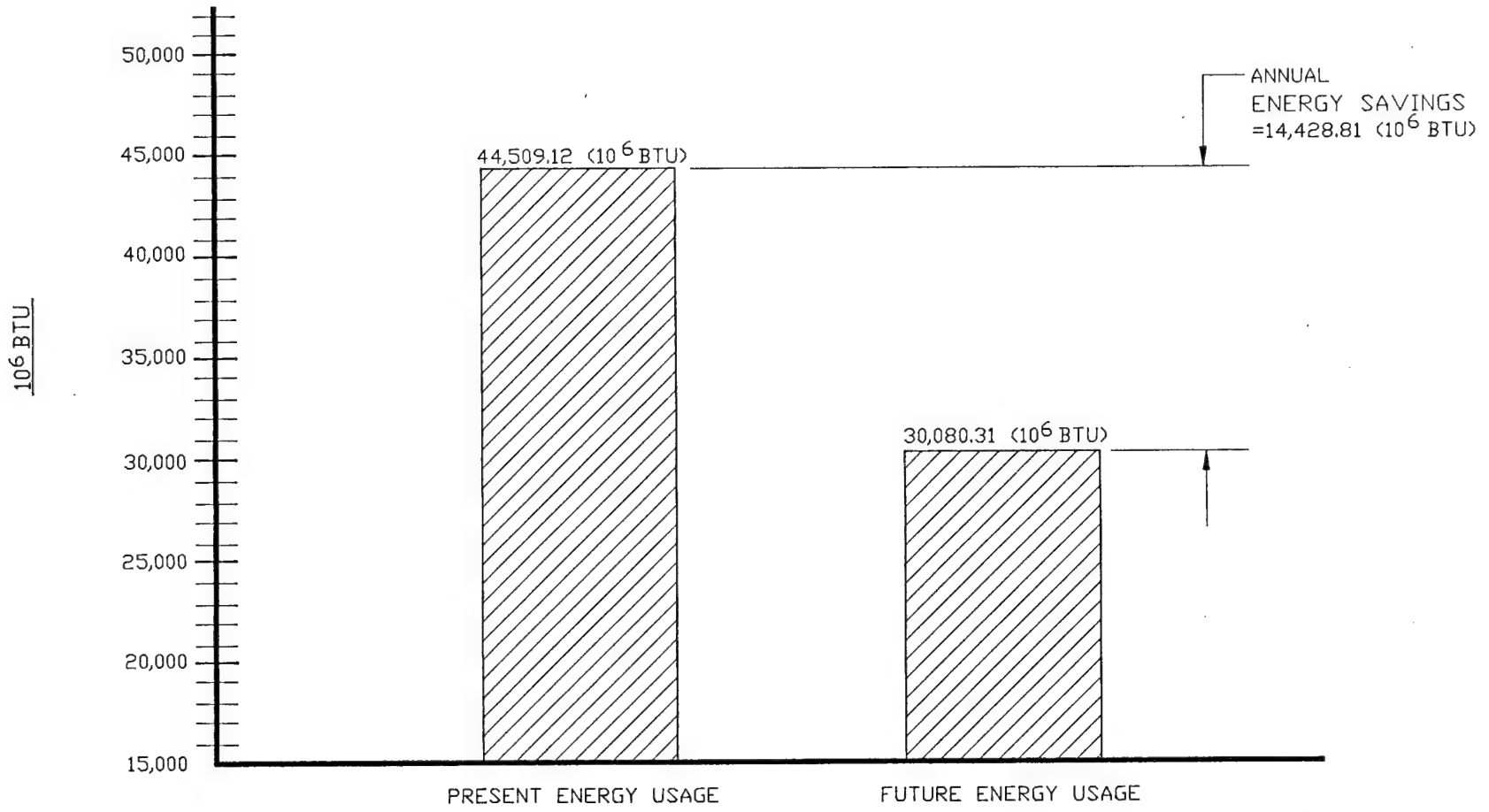
| Boiler No. | 1 | 2 |
|---|---|---|
| Manufacturer | International | International |
| Type | Water Tube | Water Tube |
| Year Built | 1976 | 1976 |
| Year Installed | 1976 | 1976 |
| Firing Equipment | Auto | Auto |
| Fuel | #6 oil | #6 oil |
| W/Pressure Design | 500 | 500 |
| Allowable Pressure | 500 | 500 |
| Safe/Valve Set | 412 | 412 |
| Serial No. | 14680 | 14679 |
| Heating Surface | | |
| Boiler | 2182 | 2182 |
| Water Wall | 328 | 328 |
| Output (Btu/hr) | 24 million HTW | 24 million HTW |

KANSAS CITY DISTRICT OFFICE - CORPS OF ENGINEERS
ENERGY ENGINEERING ANALYSIS PROGRAM
EEAP
FORT LEONARD WOOD, MISSOURI
BOILER/CHILLER PLANTS

TABLE IV

PERCENT ENERGY SAVINGS POSSIBLE AFTER
FEASIBLE ECO IMPLEMENTATION

| Building/Equipment | Savings, % |
|---|---|
| All/All | 32 |
| 311/Boilers | 0.30 |
| 645/Boilers | 3.2 |
| 745/Boilers | 3.3 |
| 1021/Boilers | 2.8 |
| All/Chillers | 33 |

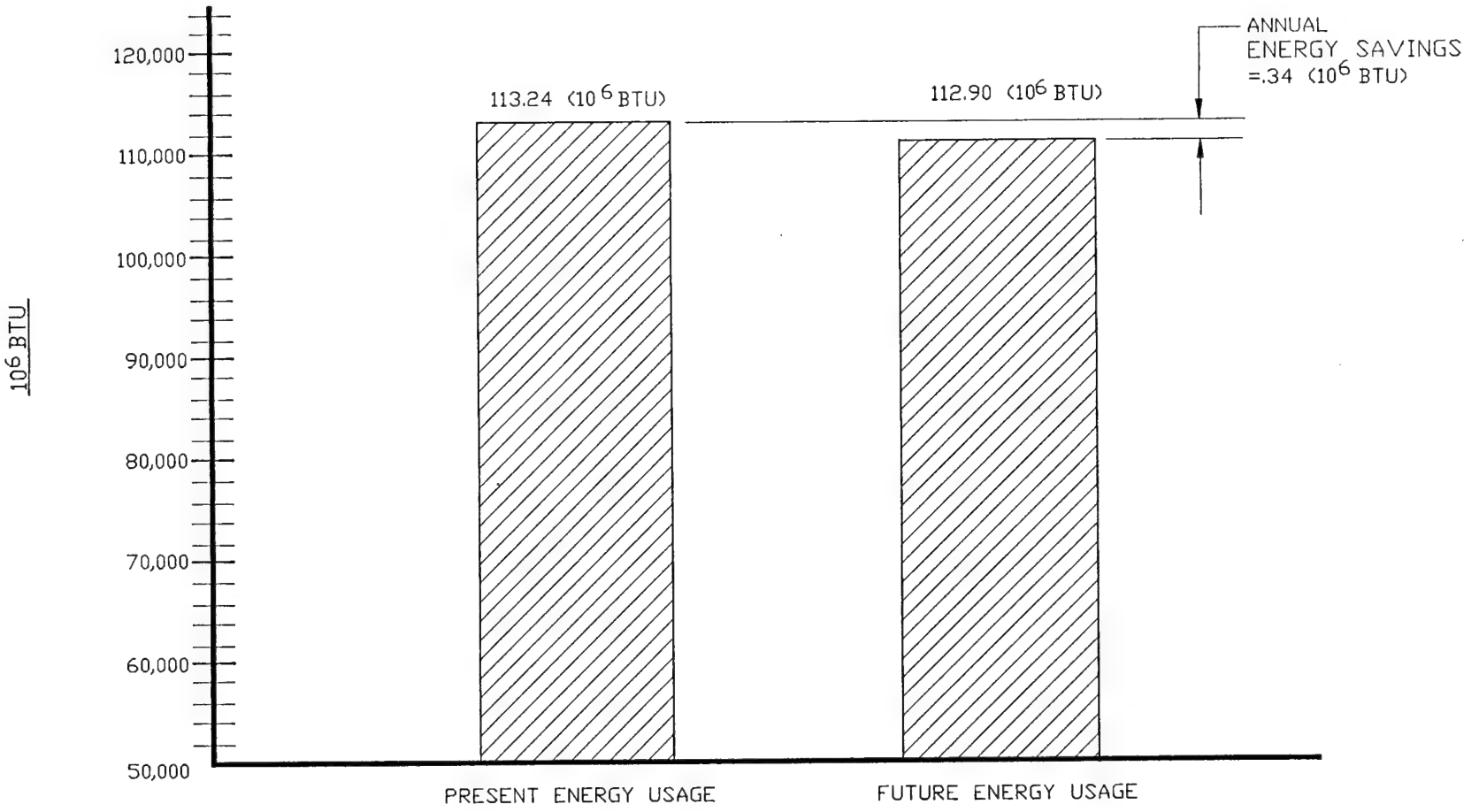



| REV. | DESCRIPTION | LUTZ, DAILY & BRAIN CONSULTING ENGINEERS P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201 DESIGN BY ____ CHECKED BY ____ DRAWN BY ____ APPROVED BY ____ | FT. LEONARD WOOD BOILER/CHILLER EEAP STUDY CONTRACT NO. DACA41-86-C-0015 | SUM OF ALL FEASIBLE ECO'S ANNUAL ENERGY SAVINGS | FIG. NO. 1 |
|---|---|---|---|---|---|



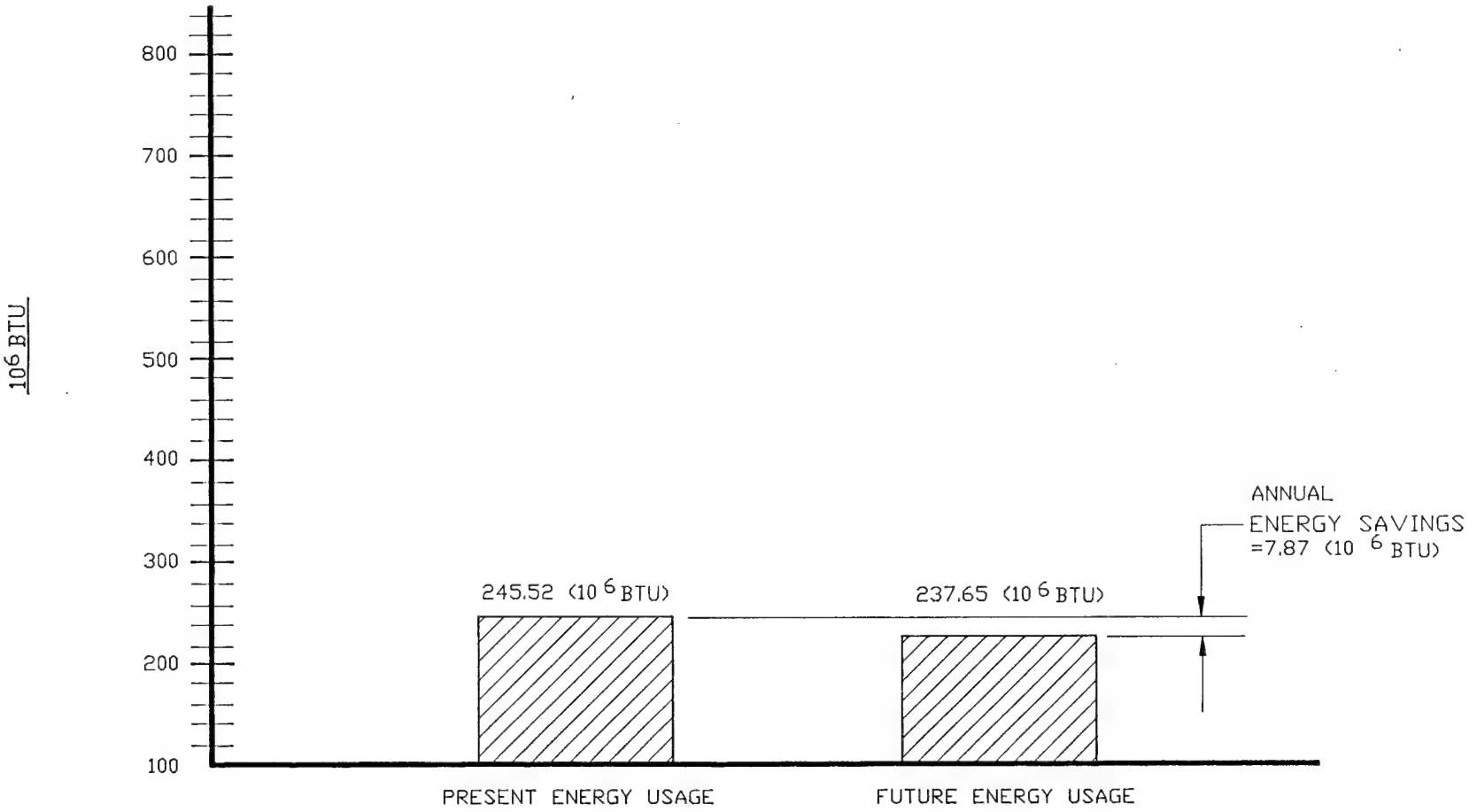
FLWGRA

31088

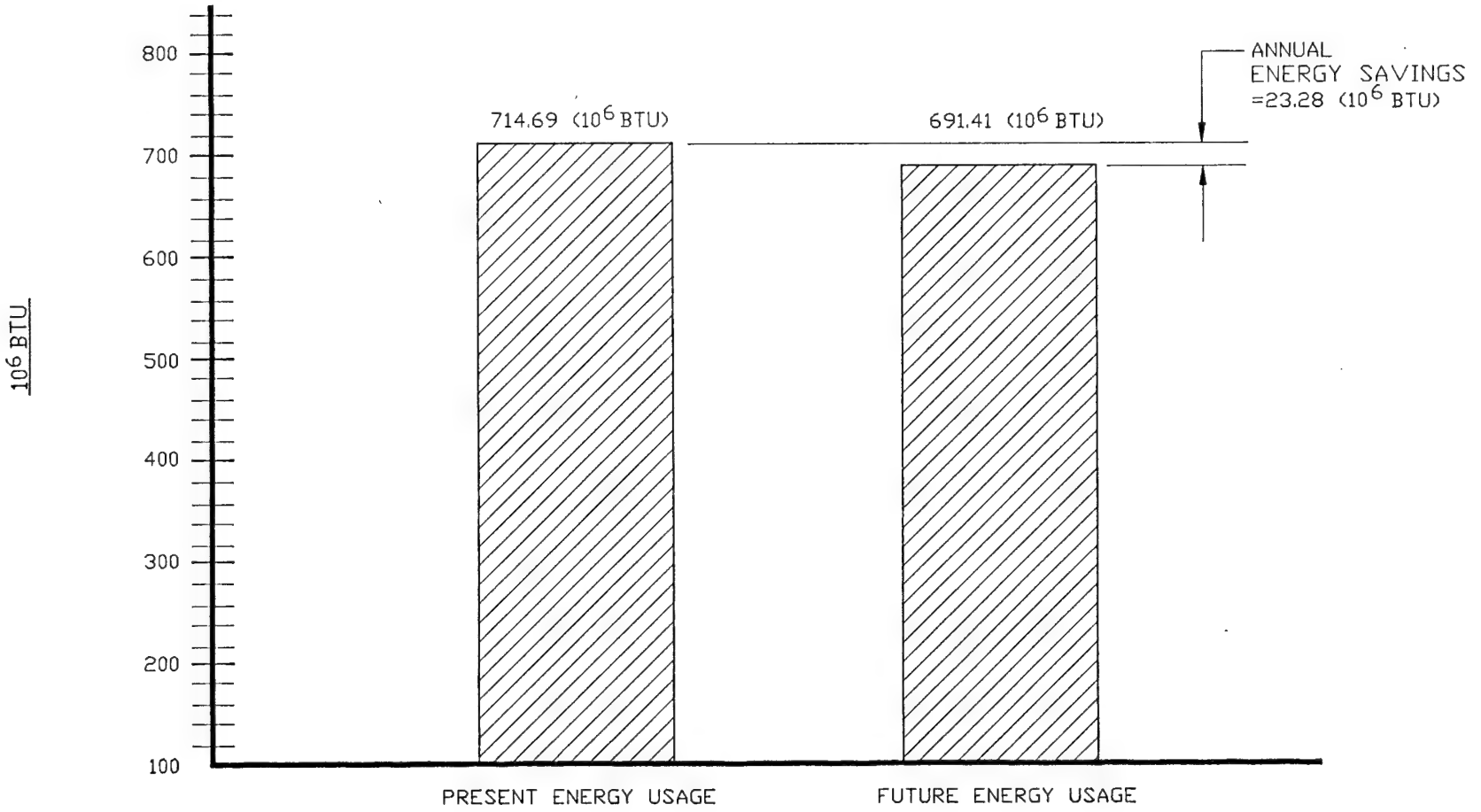



| REV. | DESCRIPTION | LUTZ, DAILY & BRAIN CONSULTING ENGINEERS P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201 DESIGN BY ____ CHECKED BY ____ DRAWN BY ____ APPROVED BY ____ | FT. LEONARD WOOD BOILER/CHILLER EEAP STUDY CONTRACT NO. DACA41-86-C-0015 | BUILDING 311 BOILER FEASIBLE ECO'S (EXCLUDING CHILLERS) | FIG. NO. 2 |
|---|---|---|---|---|---|

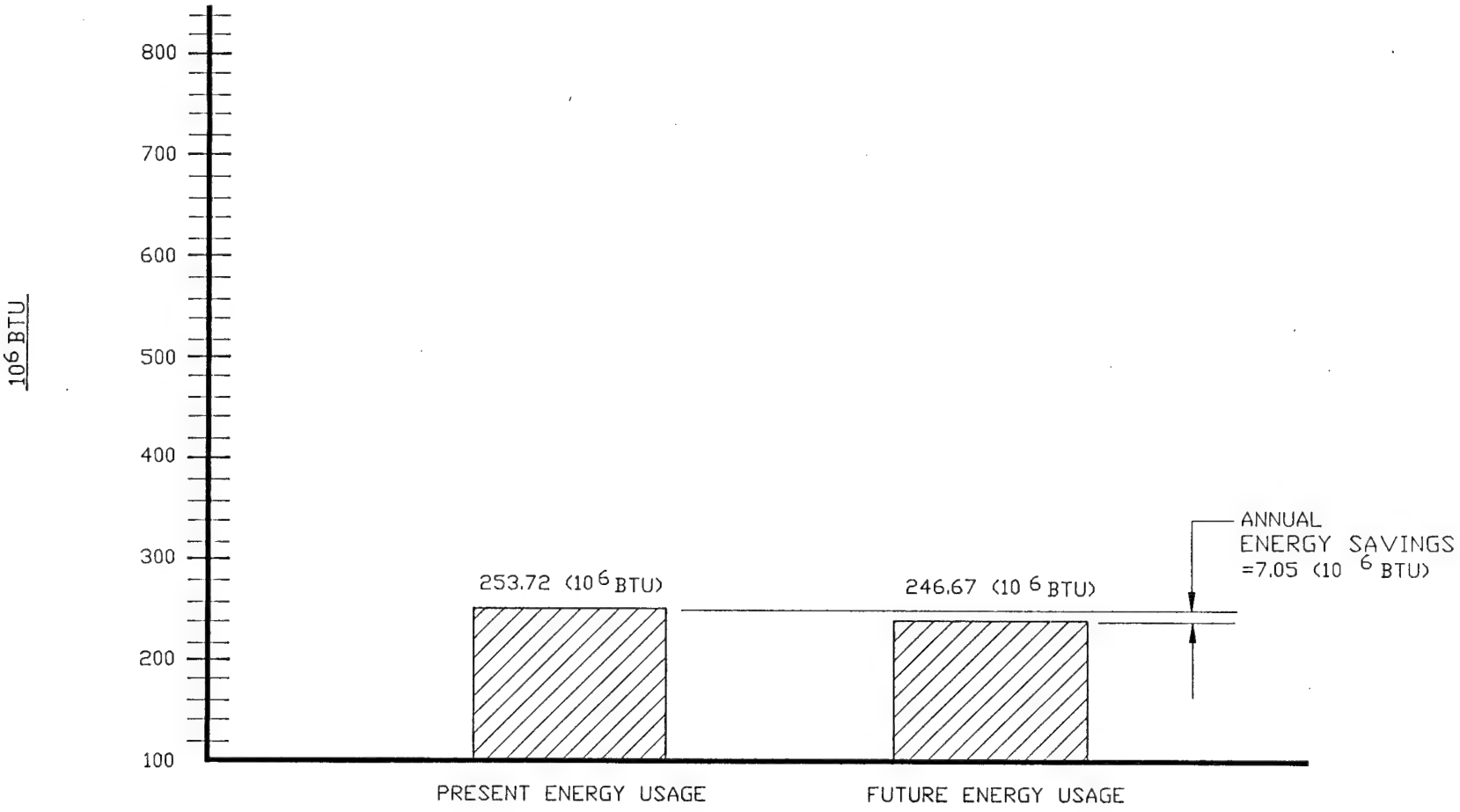
FLWGRC




| REV. | DESCRIPTION | LUTZ, DAILY & BRAIN CONSULTING ENGINEERS P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201 DESIGN BY ____ CHECKED BY ____ DRAWN BY ____ APPROVED BY ____ | FT. LEONARD WOOD BOILER/CHILLER EEAP STUDY CONTRACT NO. DACA41-86-C-0015 | BUILDING 645 BOILER FEASIBLE ECO'S | FIG. NO. 3 |
|---|---|---|---|---|---|



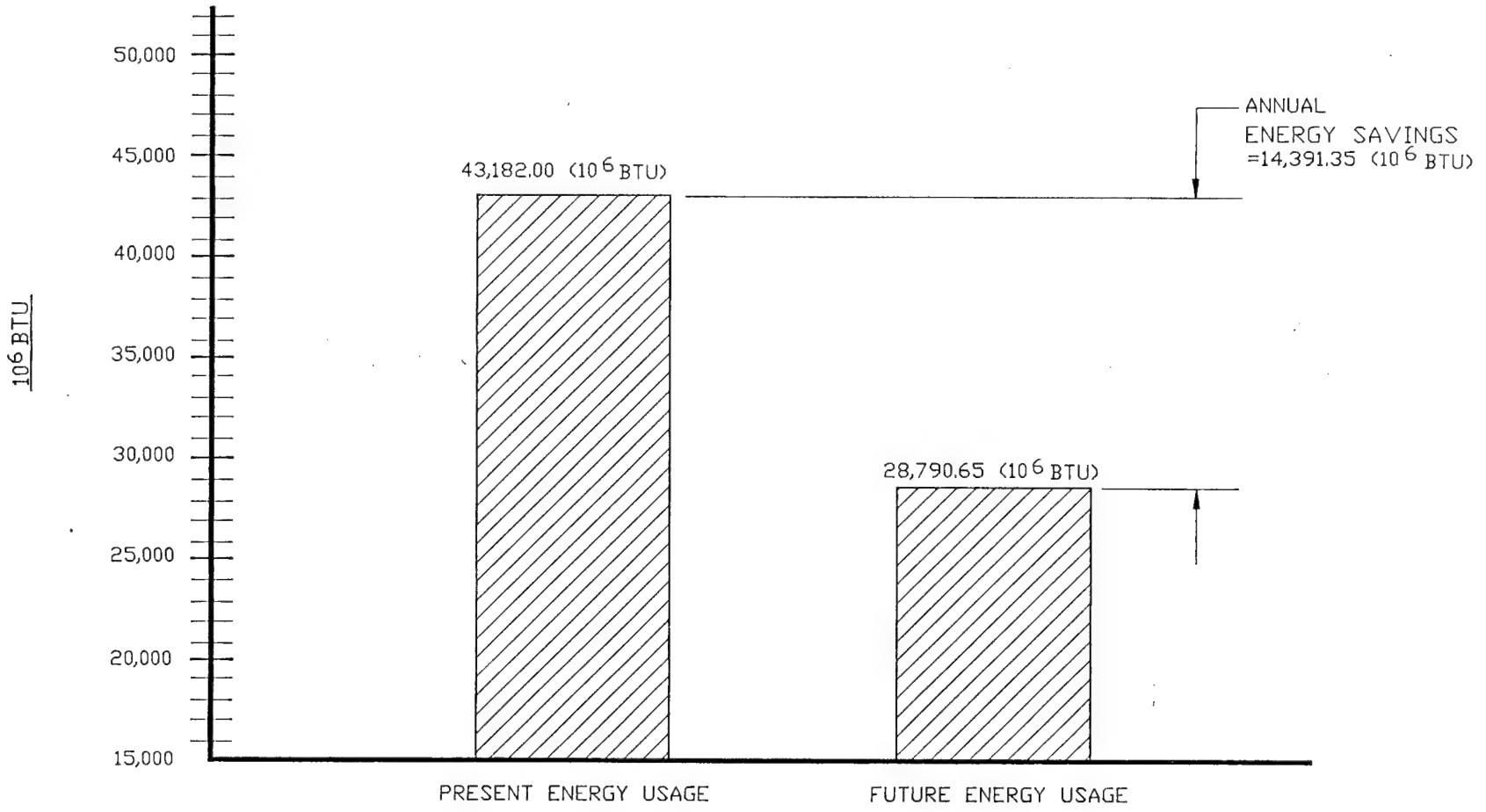

| REV. | DESCRIPTION | LUTZ, DAILY & BRAIN CONSULTING ENGINEERS P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201 DESIGN BY ____ CHECKED BY ____ DRAWN BY ____ APPROVED BY ____ | FT. LEONARD WOOD BOILER/CHILLER EEAP STUDY CONTRACT NO. DACA41-86-C-0015 | BUILDING 745 BOILER FEASIBLE ECO'S (EXCLUDING CHILLERS) | FIG. NO. 4 |
|---|---|---|---|---|---|




| REV. | DESCRIPTION | LUTZ, DAILY & BRAIN CONSULTING ENGINEERS P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201 | FT. LEONARD WOOD BOILER/CHILLER EEAP STUDY CONTRACT NO. DACA41-86-C-0015 | BUILDING 1021 BOILER FEASIBLE ECO'S (EXCLUDING CHILLER) | FIG. NO. 5 |
|---|---|---|---|---|---|
| | | DESIGN BY ____ CHECKED BY ____ DRAWN BY ____ APPROVED BY ____ | | | |



FL.WGRF




| REV. | DESCRIPTION | LUTZ, DAILY & BRAIN CONSULTING ENGINEERS P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201 DESIGN BY ____ CHECKED BY ____ DRAWN BY ____ APPROVED BY ____ | FT. LEONARD WOOD BOILER/CHILLER EEAP STUDY CONTRACT NO. DACA41-86-C-0015 | SUM OF ALL CHILLER & CHILLER DDC FEASIBLE ECO'S | FIG. NO. 6 |
|---|---|---|---|---|---|

## B. CONCLUSION

### 1. Boiler Inspections

Inspection of the boilers within the scope of this study indicates that the boilers are in satisfactory condition. With recommended repairs and proper maintenance and operation all boilers should last at least an additional ten years.

The boiler controls for all boilers in Building 745 are obsolete. Oxygen monitoring equipment has recently been outdated by new monitoring equipment which has entered the market in recent years. Existing monitoring equipment is not maintained because of soot plugging problems and a tendency of the Base to operate with high excess air. The temperature transmitters are also outdated and the flow transmitters are inaccurate. The Corps of Engineers has already replaced the boiler controls on the five boilers in Building 745 (Soliciation No. DACA41-87-B-1327).

It is recommended that outdated boiler controls, instruments and monitoring equipment be replaced.

### 2. Boiler Performance Testing

Performance testing of the boilers shows that there is a considerable amount of savings possible by reducing the excess air and flue gas temperatures in the operation of the boilers. The performance test units and the boiler descriptions are summarized in Table 1-6, Unit Description and Test Results Summary, in Volume 1 - Summary.

### 3. Boiler Recommendations

It is recommended that action be taken to reduce the amount of excess air used in the operation of the boilers as follows:

a. Install new oxygen and combustible monitoring equipment with oxygen trim.

Building 311 - Portable flue gas analyzer (only).

Building 645 - Boiler No. 3

Building 745 - Boiler No. 1
Boiler No. 4
Boiler No. 5

Building 1021 - Hot Water (HW) Generator A
HW Generator B

Building 2369 - HW Generator A
HW Generator B

b. Install new burner and controls.

Building 645 - Boiler No. 1

Building 745 - Boiler No. 1
Boiler No. 4
Boiler No. 5

Building 1021 - HW Generator A
HW Generator B

c. Complete overhaul of boiler controls - all boilers.

d. Biannual boiler control servicing - all boilers.

It is recommended that economizers be installed to reduce the exit flue gas temperature on the following boilers.

Building 645 - Boiler No. 1

Building 745 - Boiler No. 1
Boiler No. 4
Boiler No. 5

Building 2351 - Boiler No. 1
Boiler No. 2

Building 2369 - HW Generator A
HW Generator B

We also recommend the following improvements:

a. New instrumentation should be installed to allow the boiler performances to be monitored.

b. Give strict attention to updating and maintaining design information for existing and future systems and equipment.

c. Log books should be kept to record equipment maintenance and modification.

Performance testing has revealed poor burner characteristics in the Building 1021 hot water generators. These Building 1021 burners are misapplied and it is recommended that they be replaced. The burners are oversized for the loading requirements and have poor turndown characteristics. (See Volume 5 for additional information and explanation.)

It is recommended that the Operations and Maintenance personnel involved in the operation of the boilers attend Boiler Efficiency Improvement Classes. One source of this type of training is presented about every two years in St. Louis, Missouri by David F. Dyer and

Glennon Maples who are Professors of Mechanical Engineering at Auburn University in Auburn, Alabama. The enrollment fee for this class is $400 per student. Another alternative would be to have the instructors mentioned above conduct their class at the Fort Leonard Wood Base. The cost for this is $500 per day plus expenses. With their permission, portions of their Boiler Efficiency Improvement Study have been included in this report.

4. Chillers

The existing chillers in Buildings 311, 1021 and 2369 were originally designed to operate at efficiencies of 0.8 kw per ton of refrigeration. The auxiliary equipment normally used 0.2 kw per ton of refrigeration. The existing chillers were tested under various load conditions during our field activities. The test results indicated the existing chillers are operating at efficiencies ranging from 1.2 kw per nominal ton of refrigeration for chillers in Building 1021 to 1.59 kw per nominal ton of refrigeration for chillers in Building 311. Operating hours for each chiller were obtained from the Base engineering personnel for each chiller. New state-of-art centrifugal chillers are now designed to operate at 0.62 kw per nominal ton of refrigeration for this size of chillers. ECO's have been prepared for replacement of the existing chillers with new chillers. The results of each ECO indicate substantial energy savings could be realized if the ECO's are incorporated. The result of each ECO is summarized in tabular form in Volume I of this report. The following ECO's are recommended:

ECO 21 Replacement High Efficiency Chillers Bldg 311.

ECO 22 Replacement High Efficiency Chillers Bldg 1021.

ECO 23 Replacement High Efficiency Chillers Bldg 2369.

The existing chiller plants at Fort Leonard Wood operate through manual control methods. The operators start and stop the chillers, make hourly, daily and weekly adjustments to operations, and generally supervise all operations of the equipment.

The adjustments to the chillers such as which chiller should operate, chilled water supply temperatures, and when a second or third chiller should be energized are made by the operators based on existing chilled water demand and projected chilled water demand. Direct Digital Control (DDC) systems are very effective when used in multiple chiller plants. The DDC systems operate individual chillers, sequence chiller operations for multiple chiller plants, and energize associated pumps and cooling towers. The chilled water and condenser water temperatures and pressures are monitored and evaluated by the DDC and used to determine which chiller should operate, when the chiller should operate and how long the chiller should operate. The chiller operation will be in response to the individual system load characteristics. Control features include chilled water reset, low load

control, equipment sequencing, lead/lag control, cooling tower temperature control, soft loading and kw demand limiting. All of these features result in a significant energy savings for the multiple chiller plants. The results of the individual ECO's are included in Volume I tables. The following ECO's are recommended:

ECO 1 Energy Management System, DDC for Bldg 1021 Chillers.

ECO 4 Energy Management System, DDC for Bldg 2369 Chillers.

ECO 6 Energy Management System, DDC for Bldg 311 Chillers.

ECO 12 Energy Management System, DDC for Bldg 745 Chillers.

5. Life Cycle Cost Analyses

Appendix A includes the Life Cycle Cost Summary data for each individual ECO and for the ECO groupings.

# APPENDIX A

# LIFE CYCLE COST DATA

The following seven (7) pages are the Life Cycle Summary data for the project ECO groupings.

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Fort Leonard Wood, Missouri REGION NO. _____ PROJECT NUMBER _____

PROJECT TITLE New Burner & Burner Controls (ECIP) FISCAL YEAR _____

DISCRETE PORTION NAME ECO Nos. 7P, 9P, 10P, 11P, 15P, 18P

ANALYSIS DATE 12-12-88 ECONOMIC LIFE 20 YEARS PREPARED BY TFL

1. INVESTMENT

| | | | |
|---|---|---|---|
| A. | CONSTRUCTION COST | $ 490,000 | |
| B. | SIOH (5 1/2 %) | $ 26,950 | |
| C. | DESIGN COST (6%) | $ 29.400 | |
| D. | ENERGY CREDIT CALC (1A+1B+1C)X.9 | $ 491,715 | |
| E. | SALVAGE VALUE OF EXISTING EQUIPMENT | -$ 0 | |
| | | | $ 491,715 |

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

| | FUEL | COST $/MMBTU(1) | SAVINGS MMBTU/YR(2) | ANNUAL $ SAVINGS(3) | DISCOUNT FACTOR(4) | DISCOUNTED SAVINGS(5) | |
|---|---|---|---|---|---|---|---|
| A. | ELEC | $ | | $ | | $ | |
| B. | DIST | $ | | $ | | $ | |
| C. | RESID | $ | | $ | | $ | |
| D. | PROPANE | $ 3.76 | 20,357 | $ 76,522 | 16.95 | $1,297,049 | |
| E. | COAL | $ | | $ | | $ | |
| F. | TOTAL | | 20,357 | $ 76,522 | | --------> | $1,297,049 |

3. NON ENERGY SAVINGS(+) / COST(-)

| | | | |
|---|---|---|---|
| A. | ANNUAL RECURRING (+/-) | | $ |
| | (1) DISCOUNT FACTOR (TABLE A) | | |
| | (2) DISCOUNTED SAVING/COST (3A X 3A1) | | $ |

B. NON RECURRING SAVINGS (+) / COST(-)

| ITEM | SAVINGS(+) COST(-)(1) | YEAR OF OC-CURRENCE(2) | DISCOUNT FACTOR(3) | DISCOUNTED SAV-INGS(+)COST(-)(4) |
|---|---|---|---|---|
| a. | $ | | | $ |
| b. | $ | | | $ |
| c. | $ | | | $ |
| d. TOTAL | $ | | | $ |

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) / COST (-) (3A2+3Bd4) $ _____

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ _____
a IF 3D1 IS = OR > 3C GO TO ITEM 4
b IF 3D1 IS < 3C CALC SIR = (2F5+3D1) / 1F= _____
c IF 3D1b = > 1 GO TO ITEM 4
d IF 3D1b IS < 1 PROJECT DOES NOT QUALITY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1d / YEARS ECONOMIC LIFE) $ 76,522

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $1,297,049

6. DISCOUNTED SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALITY)(SIR)=(5 / 1F)= 3.20

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Fort Leonard Wood, Missouri REGION NO. _____ PROJECT NUMBER _____

PROJECT TITLE Economizer (ECIP) FISCAL YEAR _____

DISCRETE PORTION NAME ECO Nos. 14P, 16P, 17P, 20P

ANALYSIS DATE 12-12-88 ECONOMIC LIFE 20 YEARS PREPARED BY TFL

1. INVESTMENT

| | | | |
|---|---|---|---|
| A. | CONSTRUCTION COST | $ 333,000 | |
| B. | SIOH (5 1/2 %) | $ 18,315 | |
| C. | DESIGN COST (6) | $ 19,980 | |
| D. | ENERGY CREDIT CALC (1A+1B+1C)X.9 | $ 371,295 | |
| E. | SALVAGE VALUE OF EXISTING EQUIPMENT | -$ 0 | |
| | | | $ 371,295 |

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

| | FUEL | COST $/MMBTU(1) | SAVINGS MMBTU/YR(2) | ANNUAL $ SAVINGS(3) | DISCOUNT FACTOR(4) | DISCOUNTED SAVINGS(5) | |
|---|---|---|---|---|---|---|---|
| A. | ELEC | $ | | $ | | $ | |
| B. | DIST | $ | | $ | | $ | |
| C. | RESID | $ | | $ | | $ | |
| D. | PROPANE | $ 3.76 | 11,763 | $ 44,217 | 16.95 | $ 749,478 | |
| E. | COAL | $ | | $ | | $ | |
| F. | TOTAL | | 11,763 | $ 44,217 | | --------> | $ 749,478 |

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ _____
(1) DISCOUNT FACTOR (TABLE A) _____
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ _____

B. NON RECURRING SAVINGS (+) / COST(-)

| ITEM | SAVINGS(+) COST(-)(1) | YEAR OF OC-CURRENCE(2) | DISCOUNT FACTOR(3) | DISCOUNTED SAV-INGS(+)COST(-)(4) |
|---|---|---|---|---|
| a. _____ | $ | | | $ |
| b. _____ | $ | | | $ |
| c. _____ | $ | | | $ |
| d. TOTAL | $ | | | $ |

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) / COST (-) (3A2+3Bd4) $ _____

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ _____
a IF 3D1 IS = OR > 3C GO TO ITEM 4
b IF 3D1 IS < 3C CALC SIR = (2F5+3D1) / 1F= _____
c IF 3D1b = > 1 GO TO ITEM 4
d IF 3D1b IS < 1 PROJECT DOES NOT QUALITY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1d / YEARS ECONOMIC LIFE) $ 44,217

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 749,478

6. DISCOUNTED SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALITY)(SIR)=(5 / 1F)= 2.72

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Fort Leonard Wood, Missouri REGION NO. _____ PROJECT NUMBER _____

PROJECT TITLE New Chillers (ECIP) FISCAL YEAR _____

DISCRETE PORTION NAME ECO Nos. 21, 22, 23

ANALYSIS DATE 2/12/88 ECONOMIC LIFE 20 YEARS PREPARED BY TFL

1. INVESTMENT

| | | | |
|---|---|---|---|
| A. | CONSTRUCTION COST | $ 943,000 | |
| B. | SIOH (5 1/2 %) | $ 51,865 | |
| C. | DESIGN COST (6%) | $ 56,580 | |
| D. | ENERGY CREDIT CALC (1A+1B+1C)X.9 | $1,051,445 | |
| E. | SALVAGE VALUE OF EXISTING EQUIPMENT | -$ 0 | |
| | | | $ 1,051,445 |

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

| FUEL | COST $/MMBTU(1) | SAVINGS MMBTU/YR(2) | ANNUAL $ SAVINGS(3) | DISCOUNT FACTOR(4) | DISCOUNTED SAVINGS(5) |
|---|---|---|---|---|---|
| A. ELEC | $ 13.98 | 10,292 | $ 143,882 | 10.02 | $1,441,697 |
| B. DIST | $ | | $ | | $ |
| C. RESID | $ | | $ | | $ |
| D. PROPANE | $ | | $ | | $ |
| E. COAL | $ | | $ | | $ |
| F. TOTAL | | 10,292 | $ 143,882 | --------> | $1,441,697 |

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ _____
(1) DISCOUNT FACTOR (TABLE A) _____
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ _____

B. NON RECURRING SAVINGS (+) / COST(-)

| ITEM | SAVINGS(+) COST(-)(1) | YEAR OF OCCURRENCE(2) | DISCOUNT FACTOR(3) | DISCOUNTED SAVINGS(+)COST(-)(4) |
|---|---|---|---|---|
| a. _____ | $ _____ | _____ | _____ | $ _____ |
| b. _____ | $ _____ | _____ | _____ | $ _____ |
| c. _____ | $ _____ | _____ | _____ | $ _____ |
| d. TOTAL | $ _____ | | | $ _____ |

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) / COST (-) (3A2+3Bd4) $ _____

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ _____
a IF 3D1 IS = OR > 3C GO TO ITEM 4
b IF 3D1 IS < 3C CALC SIR = (2F5+3D1) / 1F= _____
c IF 3D1b = > 1 GO TO ITEM 4
d IF 3D1b IS < 1 PROJECT DOES NOT QUALITY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1d / YEARS ECONOMIC LIFE) $ 143,882

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $1,441,697

6. DISCOUNTED SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALITY)(SIR)=(5 / 1F)= 1.85

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Fort Leonard Wood, Missouri REGION NO. _____ PROJECT NUMBER _____

PROJECT TITLE Chiller Direct Digital Control System (QRIP) FISCAL YEAR _____

DISCRETE PORTION NAME ECO Nos. 1, 6, 4, 12

ANALYSIS DATE 12-12-88 ECONOMIC LIFE 20 YEARS PREPARED BY TFL

1. INVESTMENT

| | | | |
|---|---|---|---|
| A. | CONSTRUCTION COST | $ 132,270 | |
| B. | SIOH | $ 0 | |
| C. | DESIGN COST | $ 0 | |
| D. | ENERGY CREDIT CALC (1A+1B+1C)X.9 | $ 119,043 | |
| E. | SALVAGE VALUE OF EXISTING EQUIPMENT | -$ 0 | |
| | | | $ 119,043 |

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

| | FUEL | COST $/MMBTU(1) | SAVINGS MMBTU/YR(2) | ANNUAL $ SAVINGS(3) | DISCOUNT FACTOR(4) | DISCOUNTED SAVINGS(5) |
|---|---|---|---|---|---|---|
| A. | ELEC | $ 13.98 | 6,000 | $ 83,880 | 10.02 | $ 840,478 |
| B. | DIST | $ | | $ | | $ |
| C. | RESID | $ | | $ | | $ |
| D. | NG | $ | | $ | | $ |
| E. | COAL | $ | | $ | | $ |
| F. | TOTAL | | 6,000 | $ 83,880 | --------> | $ 840,478 |

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ _____
(1) DISCOUNT FACTOR (TABLE A) _____
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ _____

B. NON RECURRING SAVINGS (+) / COST(-)

| ITEM | SAVINGS(+) COST(-)(1) | YEAR OF OCCURRENCE(2) | DISCOUNT FACTOR(3) | DISCOUNTED SAVINGS(+)COST(-)(4) |
|---|---|---|---|---|
| a. _____ | $ _____ | _____ | _____ | $ _____ |
| b. _____ | $ _____ | _____ | _____ | $ _____ |
| c. _____ | $ _____ | _____ | _____ | $ _____ |
| d. TOTAL | $ _____ | | | $ _____ |

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) / COST (-) (3A2+3Bd4) $ _____

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ _____
a IF 3D1 IS = OR > 3C GO TO ITEM 4
b IF 3D1 IS < 3C CALC SIR = (2F5+3D1) / 1F= _____
c IF 3D1b = > 1 GO TO ITEM 4
d IF 3D1b IS < 1 PROJECT DOES NOT QUALITY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1d / YEARS ECONOMIC LIFE) $ 83,880

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 840,478

6. DISCOUNTED SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALITY)(SIR)=(5 / 1F)= 6.35

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Fort Leonard Wood, Missouri REGION NO. _____ PROJECT NUMBER _____

PROJECT TITLE Flue Gas Analyzer FISCAL YEAR _____

DISCRETE PORTION NAME ECO No. 2P

ANALYSIS DATE 12-12-88 ECONOMIC LIFE 20 YEARS PREPARED BY TFL

1. INVESTMENT

| | | | |
|---|---|---|---|
| A. | CONSTRUCTION COST | $ 3,400 | |
| B. | SIOH | $ 0 | |
| C. | DESIGN COST | $ 0 | |
| D. | ENERGY CREDIT CALC (1A+1B+1C)X.9 | $ 3,060 | |
| E. | SALVAGE VALUE OF EXISTING EQUIPMENT | -$ 0 | |
| | | | $ 3,060 |

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

| FUEL | COST $/MMBTU(1) | SAVINGS MMBTU/YR(2) | ANNUAL $ SAVINGS(3) | DISCOUNT FACTOR(4) | DISCOUNTED SAVINGS(5) |
|---|---|---|---|---|---|
| A. ELEC | $ | | $ | | $ |
| B. DIST | $ | | $ | | $ |
| C. RESID | $ | | $ | | $ |
| D. PROPANE | $ 3.76 | 333 | $ 1,252 | 16.95 | $ 21,221 |
| E. COAL | $ | | $ | | $ |
| F. TOTAL | | 333 | $ 1,252 | --------> | $ 21,221 |

3. NON ENERGY SAVINGS(+) / COST(-)
A. ANNUAL RECURRING (+/-) $ _____
(1) DISCOUNT FACTOR (TABLE A) _____
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ _____

B. NON RECURRING SAVINGS (+) / COST(-)

| ITEM | SAVINGS(+) COST(-)(1) | YEAR OF OCCURRENCE(2) | DISCOUNT FACTOR(3) | DISCOUNTED SAVINGS(+)COST(-)(4) |
|---|---|---|---|---|
| a. _____ | $ | | | $ |
| b. _____ | $ | | | $ |
| c. _____ | $ | | | $ |
| d. TOTAL | $ | | | $ |

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) / COST (-) (3A2+3Bd4) $ _____

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ _____
a IF 3D1 IS = OR > 3C GO TO ITEM 4
b IF 3D1 IS < 3C CALC SIR = (2F5+3D1) / 1F= _____
c IF 3D1b = > 1 GO TO ITEM 4
d IF 3D1b IS < 1 PROJECT DOES NOT QUALITY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1d / YEARS ECONOMIC LIFE) $ 1,252

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 21,221

6. DISCOUNTED SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALITY)(SIR)=(5 / 1F)= 6.28

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Fort Leonard Wood, Missouri REGION NO. _____ PROJECT NUMBER _____

PROJECT TITLE Flue Gas Monitoring Equipment & Oxygen Trim FISCAL YEAR _____
with Burner Replacement

DISCRETE PORTION NAME ECO Nos. 3P, 5P, 8P, 13P, 24P

ANALYSIS DATE 12-12-88 ECONOMIC LIFE 20 YEARS PREPARED BY TFL

1. INVESTMENT

| | | | |
|---|---|---|---|
| A. | CONSTRUCTION COST | $ 98,500 | |
| B. | SIOH | $ 0 | |
| C. | DESIGN COST | $ 0 | |
| D. | ENERGY CREDIT CALC (1A+1B+1C)X.9 | $ 88,650 | |
| E. | SALVAGE VALUE OF EXISTING EQUIPMENT | -$ 0 | |
| | | | $ 88,650 |

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

| | FUEL | COST $/MMBTU(1) | SAVINGS MMBTU/YR(2) | ANNUAL $ SAVINGS(3) | DISCOUNT FACTOR(4) | DISCOUNTED SAVINGS(5) |
|---|---|---|---|---|---|---|
| A. | ELEC | $ | | $ | | $ |
| B. | DIST | $ | | $ | | $ |
| C. | RESID | $ | | $ | | $ |
| D. | PROPANE | $ 3.76 | 5,008 | $ 18,826 | 16.95 | $ 319,101 |
| E. | COAL | $ | | $ | | $ |
| F. | TOTAL | | 5,008 | $ 18,826 | --------> | $ 319,101 |

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ _____
(1) DISCOUNT FACTOR (TABLE A) _____
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ _____

B. NON RECURRING SAVINGS (+) / COST(-)

| ITEM | SAVINGS(+) COST(-)(1) | YEAR OF OCCURRENCE(2) | DISCOUNT FACTOR(3) | DISCOUNTED SAVINGS(+)COST(-)(4) |
|---|---|---|---|---|
| a. _____ | $ _____ | _____ | _____ | $ _____ |
| b. _____ | $ _____ | _____ | _____ | $ _____ |
| c. _____ | $ _____ | _____ | _____ | $ _____ |
| d. TOTAL | $ _____ | | | $ _____ |

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) / COST (-) (3A2+3Bd4) $ _____

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ _____
a IF 3D1 IS = OR > 3C GO TO ITEM 4
b IF 3D1 IS < 3C CALC SIR = (2F5+3D1) / 1F= _____
c IF 3D1b = > 1 GO TO ITEM 4
d IF 3D1b IS < 1 PROJECT DOES NOT QUALITY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1d / YEARS ECONOMIC LIFE) $ 18,826

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 319,101

6. DISCOUNTED SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALITY)(SIR)=(5 / 1F)= 3.26

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Fort Leonard Wood, Missouri REGION NO. _____ PROJECT NUMBER _____

PROJECT TITLE Flue Gas Monitoring Equipment and Oxygen Trim (LC/NC) FISCAL YEAR ____

DISCRETE PORTION NAME ECO No. 19P

ANALYSIS DATE 12-12-88 ECONOMIC LIFE 20 YEARS PREPARED BY TFL

1. INVESTMENT

| | | | |
|---|---|---|---|
| A. | CONSTRUCTION COST | $ 19,700 | |
| B. | SIOH | $ 0 | |
| C. | DESIGN COST | $ 0 | |
| D. | ENERGY CREDIT CALC (1A+1B+1C)X.9 | $ 17,730 | |
| E. | SALVAGE VALUE OF EXISTING EQUIPMENT | -$ 0 | |
| | | | $ 17,730 |

2. ENERGY SAVINGS (+) / COST (-)
ANALYSIS DATE ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

| | FUEL | COST $/MMBTU(1) | SAVINGS MMBTU/YR(2) | ANNUAL $ SAVINGS(3) | DISCOUNT FACTOR(4) | DISCOUNTED SAVINGS(5) |
|---|---|---|---|---|---|---|
| A. | ELEC | $ | | $ | | $ |
| B. | DIST | $ | | $ | | $ |
| C. | RESID | $ | | $ | | $ |
| D. | PROPANE | $ 3.76 | 806 | $ 3,030 | 16.95 | $ 51,359 |
| E. | COAL | $ | | $ | | $ |
| F. | TOTAL | | 806 | $ 3,030 | --------> | $ 51,359 |

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ _____
(1) DISCOUNT FACTOR (TABLE A) _____
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ _____

B. NON RECURRING SAVINGS (+) / COST(-)

| ITEM | SAVINGS(+) COST(-)(1) | YEAR OF OCCURRENCE(2) | DISCOUNT FACTOR(3) | DISCOUNTED SAVINGS(+)COST(-)(4) |
|---|---|---|---|---|
| a. | $ | | | $ |
| b. | $ | | | $ |
| c. | $ | | | $ |
| d. TOTAL | $ | | | $ |

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) / COST (-) (3A2+3Bd4) $ _____

D. PROJECT NON ENERGY QUALIFICATION TEST
(1) 25% MAX NON ENERGY CALC (2F5 X .33) $ _____
a IF 3D1 IS = OR > 3C GO TO ITEM 4
b IF 3D1 IS < 3C CALC SIR = (2F5+3D1) / 1F= _____
c IF 3D1b = > 1 GO TO ITEM 4
d IF 3D1b IS < 1 PROJECT DOES NOT QUALITY

4. FIRST YEAR DOLLAR SAVINGS 2F3+3A+(3B1d / YEARS ECONOMIC LIFE) $ 3,030

5. TOTAL NET DISCOUNTED SAVINGS (2F5+3C) $ 51,359

6. DISCOUNTED SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALITY)(SIR)=(5 / 1F)= 2.63